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[Title of the Invention] LIQUID CRYSTAL DEVICE, AND THE MANUFACTURING METHOD

[Scope of the Claims]

[Claim 1]

A liquid crystal device, comprising:

a pair of substrates which sandwich liquid crystal;

a light reflecting film formed on at least one of the substrates; and

a color filter formed on the light reflecting film,

wherein the color filter includes a partitioning member, which divides the surface of the substrate into a plurality of sections, and subpixels, which are formed in the plurality of sections, and

wherein openings are formed in the light reflecting film at regions corresponding to thickest parts of the subpixels.

[Claim 2]

A liquid crystal device, comprising:

a pair of substrates which sandwich liquid crystal;

a light reflecting film formed on at least one of the substrates; and

a color filter formed on the light reflecting film, wherein the color filter includes a partitioning member, which divides the surface of the substrate into a plurality of sections, and subpixels, which are formed in the plurality of sections, and

wherein openings are formed in the light reflecting film at regions corresponding to central parts of the plurality of sections.

[Claim 3]

A liquid crystal device, comprising:

a pair of substrates which sandwich liquid crystal;

a light reflecting film formed on at least one of the substrates; and

a color filter formed on the light reflecting film,

wherein the color filter includes a partitioning member, which divides the surface of the substrate into a plurality of rectangular sections, and subpixels, which are formed in the plurality of sections, and

wherein openings are formed in the light reflecting film in such a manner that the openings extend in the longitudinal direction of the plurality of rectangular sections.

[Claim 4]

A liquid crystal device, comprising:

a pair of substrates which sandwich liquid crystal;

a light reflecting film formed on at least one of the substrates; and

a color filter formed on the light reflecting film, wherein the color filter includes a partitioning member, which divides the surface of the substrate into a plurality of sections, and subpixels, which are formed in the plurality of sections, and

wherein openings are formed in the light reflecting film in such a manner that the openings have a shape corresponding to the thickness of the subpixels.

[Claim 5]

The liquid crystal device according to at least one of Claims 1-4, wherein the openings have a shape such that the corners thereof are chamfered.

[Claim 6]

The liquid crystal device according to at least one of Claims 1-5, wherein the planner shape of opening is a rectangular shape, an oval shape, or an elliptical shape.

[Claim 7]

The liquid crystal device according to at least one of Claims 1-6, wherein the area of a single opening is 5% to 30%, preferably 20% of one area of the plurality of sections.

[Claim 8]

A manufacturing method for a liquid crystal device, in which liquid crystal is sandwiched between a pair of substrates, at least one of which includes a color filter, the manufacturing method for a liquid crystal device, comprising the steps of:

forming a light reflecting film on one of the substrates;

forming a partitioning member which divides the surface of the substrate into a plurality of sections; and

forming subpixels in the plurality of sections divided by the partitioning member,

wherein the step of forming the subpixels includes the step of ejecting, in the form of drops, a material for forming the subpixels from nozzles toward the plurality of sections and

wherein the step of forming the light reflecting film includes the step of forming openings in the light reflecting film at regions corresponding to the plurality of sections.

[Claim 9]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the openings are formed in the light reflecting film at regions corresponding to thickest parts of the subpixels.

[Claim 10]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the openings are formed in the light reflecting film at regions corresponding to central parts of the plurality of sections.

[Claim 11]

The manufacturing method for a liquid crystal device according to Claim 8, wherein

in the step of forming the partitioning member, the surface of the substrate is divided into a plurality of rectangular sections, and in the step of forming the light reflecting film, the long openings are formed in the light reflecting film in such a manner that the openings extend in the longitudinal direction of the plurality of rectangular sections.

[Claim 12]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the openings are formed in the light reflecting film in such a manner that the openings have a shape corresponding to the thickness of the subpixels.

[Claim 13]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the openings having a shape such that the corners thereof are chamfered are formed in the light reflecting film.

[Claim 14]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the planner shape of opening being a rectangular shape, an oval shape, or an elliptical shape are formed in the light reflecting film.

[Claim 15]

The manufacturing method for a liquid crystal device according to Claim 8, wherein, in the step of forming the light reflecting film, the openings are formed in the light reflecting film in such a manner that the area of a single opening is 5% to 30%, preferably 20% of one area of the plurality of sections.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to transflective liquid crystal devices with which reflective display using light that is reflected after passing through a liquid crystal layer and transmissive display using light that is transmitted through the liquid crystal layer can both be realized, and in which a color filter is disposed on a light path so that color display can be realized.

[0002]

[Prior Art]

Recently, liquid crystal devices have come into widespread use in electronic devices such as mobile phones, portable personal computers, etc. In such liquid crystal devices, reflective liquid crystal devices, in which a light reflecting film is provided on an inside or outside surface of a substrate disposed at the side opposite to the observer's side of a liquid crystal layer, are known in the art. In reflective liquid crystal devices, light incident from the observer's side is reflected at the light reflecting film, and is used as a light source for display.

[0003]

In addition, transmissive type display liquid crystal devices, in which an illuminating device, i.e., a so-called backlight is disposed at the side opposite to the observer's side of a liquid crystal layer and is used as a light source for display, are also known in the art. In addition, so-called transflective display liquid crystal devices, in which openings are partially formed in a light reflecting film, and in which reflective display is realized using light reflective regions excluding the openings in the light reflecting film and transmissive display is realized using the light going through the openings in the light reflecting film, are also known in the art.

[0004]

On the other hand, recently, color display is often realized in liquid crystal devices by disposing a color filter having R (red), G (green), and B (blue) or C (cyan), M (magenta), Y (yellow), or the like subpixels, in a display area of the liquid crystal devices.

[0005]

[Problems to be Solved by the Invention]

According to a known technique of color transflective displays, in which openings are formed in a light reflecting film and a color filter is used, uniform color display over the display area could not be realized. The inventors have performed various experiments for finding the reason for this, and found that color display cannot be made uniform if the relationship between the openings in the light reflecting film and the R, G, B or the like subpixels regarding position and shape are not adequately coordinated.

[0006]

In view of the above-described finding, an object of this invention is to provide a transflective liquid crystal device in which color display can be made uniform over the display surface at the time of both the reflective display and the transmissive display.

[0007]

[Means for Solving the Problems]

(1) In order to attain the above-described object, according to a first aspect of this invention, a liquid crystal device comprises a pair of substrates which sandwich liquid crystal; a light reflecting film formed on at least one of the substrates; and a color filter formed on the light reflecting film. The color filter includes a partitioning member, which divides the surface of the substrate into a plurality of sections, and subpixels, which are formed in the plurality of sections, and openings are formed in the light reflecting film at regions corresponding to thickest parts of the subpixels.

[0008]

The partitioning member may be formed by, for example, applying an ink-repellent resin at a uniform thickness by a known deposition method, for example, spin coating, and forming a predetermined pattern by a known patterning method, for example, photolithography. In addition, the above-described subpixels are formed by, for example, an ink jet method, that is, by ejecting, in the form of drops, a subpixel material from nozzles of an ink jet head toward the sections divided by the partitioning member.

[0009]

In the liquid crystal device according to the first aspect of this invention, as shown in Fig. 5, for example, openings 18 are formed in a light reflecting film 9 at regions corresponding to thickest parts of subpixels 16. Thus, at the time of the reflective display, as shown by the arrow X0, light going through the subpixels 16 to and from the light reflecting film 9 at parts excluding the thickest parts of the subpixels 16 is used for color display. Meanwhile, at the time of the transmissive display, light going through the subpixels 16 at thickest parts thereof is used for color display.

[0010]

Accordingly, light that is transmitted through the subpixels 16 once at the thickest parts thereof is used in the transmissive display mode, and light that is transmitted through the subpixels 16 twice at thin parts thereof is used in the reflective display mode. Accordingly, the optical film thickness in the reflective display mode and in the transmissive display mode can be made close or approximately the same, so color display can be made uniform between the reflective display mode and the transmissive display mode.

[0011]

(2) According to a second aspect of this invention, a liquid crystal device comprises a pair of substrates which sandwich liquid crystal; a light reflecting film formed on at least one of the substrates; and a color filter formed on the light reflecting film. The color filter includes a partitioning member, which divides the surface of the substrate into a plurality of

sections, and subpixels, which are formed in the sections, and openings are formed in the light reflecting film at regions corresponding to central parts of the plurality of sections.

[0012]

The partitioning member may be formed by, for example, applying an ink-repellent resin at a uniform thickness by a known deposition method, for example, spin coating, and forming a predetermined pattern by a known patterning method, for example, photolithography. In addition, the above-described subpixels are formed by, for example, the ink jet method, that is, by ejecting, in the form of drops, a subpixel material from nozzles of an ink jet head toward the sections divided by the partitioning member.

[0013]

As shown in Fig. 5(a) and Fig. 5(c), when the subpixels 16 are formed by the ink jet method, central regions of the sections divided by the partitioning member 14 tend to be projected. Accordingly, when the openings 18 are formed in the light reflecting film 9 at regions corresponding to the central parts, the optical film thickness in the reflective display mode and in the transmissive display mode can be made close or approximately the same. Thus, color display can be made uniform between the reflective display mode and the transmissive display mode.

(3) According to a third aspect of this invention, a liquid crystal device comprises a pair of substrates which sandwich liquid crystal; a light reflecting film formed on at least one of the substrates; and a color filter formed on the light reflecting film. The color filter

includes a partitioning member, which divides the surface of the substrate into a plurality of rectangular sections, and subpixels, which are formed in the plurality of sections, and openings are formed in the light reflecting film in such a manner that the openings extend in the longitudinal direction of the plurality of rectangular sections.

[0014]

The partitioning member may be formed by, for example, applying an ink-repellent resin at a uniform thickness by a known deposition method, for example, spin coating, and forming a predetermined pattern by a known patterning method, for example, photolithography. In addition, the above-described subpixels are formed by, for example, the ink jet method, that is, by ejecting, in the form of drops, a subpixel material from nozzles of an ink jet head toward the sections divided by the partitioning member.

[0015]

Generally, in order to realize color display, especially, full-color display, a unit consisting of R, G, and B pixels is formed as a pixel, and full color is displayed depending on the color illuminated in each pixel. The individual R, G, and B pixels are often formed in a rectangular shape. In such a case, as shown in Fig. 5(b), the partitioning member 14 forms a plurality of rectangular sections, and the subpixels 16 are individually formed in the rectangular sections.

[0016]

When the subpixels 16 are formed in the rectangular shape in a plan manner, the openings 18 are preferably formed in a rectangular shape of the light reflecting film that extends in the longitudinal direction of the subpixels 16. Accordingly, in the transmissive display mode, a sufficient amount of light that is uniform in the longitudinal direction of the subpixels 16 can be supplied to the subpixels 16, so uniform color display can be realized.

[0017]

(4) According to a fourth aspect of this invention, a liquid crystal device comprises a pair of substrates which sandwich liquid crystal; a light reflecting film formed on at least one of the substrates; and a color filter formed on the light reflecting film. The color filter includes a partitioning member, which divides the surface of the substrate into a plurality of sections, and subpixels, which are individually formed in the plurality of sections, and openings are formed in the light reflecting film in such a manner that the openings have a shape corresponding to the thickness of the subpixels.

[0018]

The partitioning member may be formed by, for example, applying an ink-repellent resin at a uniform thickness by a known deposition method, for example, spin coating, and forming a predetermined pattern by a known patterning method, for example, photolithography. In addition, the above-described subpixels are formed by, for example, the ink jet method, that is, by ejecting, in the form of drops, a subpixel material from nozzles of an ink jet head toward the sections divided by the partitioning member.

[0019]

When the subpixels are formed by supplying ink, that is, a subpixel material to the sections divided by the partitioning member based on the ink jet method, the thickness of the subpixels may not be necessarily constant in a plan manner. For example, as shown in Fig. 5(a) and Fig. 5(c), the subpixels 16 may be formed in a convex shape, in other words, shaped like a dome. When the thickness of the subpixels 16 is not uniform in a plan manner, for example, the openings 18 are preferably formed only at regions corresponding to the parts of the subpixels 16 where the thickness thereof is larger than a reference value T0. Accordingly, the color display can be made more uniform between the reflective display mode and the transmissive display mode.

[0020]

When the openings are formed in the light reflecting film in the shape corresponding to the thickness of the subpixels, the shape of the openings is effectively determined by utilizing light interference fringes. Specifically, as shown in Fig. 8(a), natural light R0 is irradiated to the subpixel 16, and light reflected form the light reflecting film 9 is shot by a camera 30. Then, when the shot image is displayed on a screen such as a display portion, interference fringes F, which are schematically shown in Fig. 8(b), are obtained in accordance with the thickness of the subpixel 16. The interference fringes F can be considered as contour lines of the surface of the subpixel 16. Accordingly, when the openings 18 are formed in the light reflecting film in the shape of one of the interference fringes F which is selected, the openings having a shape that accurately corresponds to the thickness of the subpixels can be obtained.

[0021]

In the liquid crystal device according to the above-described first to fourth aspects of this invention, the openings arranged in the light reflecting film preferably have a planner shape such that the corners thereof are chamfered. For example, the corners of the openings may be formed as linear chamfers M1 shown in Fig. 6(b) or curved chamfers M2 shown in Fig. 7(b).

[0022]

In general, the subpixels formed in the sections divided by the partitioning member tend to have a shape such that the central parts thereof are projected and the parts close to the partitioning member become low. In addition, the surfaces of the subpixels are curved in three-dimensional space along the diagonal lines of the divided sections. In such a case, when the corners of the openings in the light reflecting film are formed in an angular shape of, for example, 90°, color uniformity may be degraded at the portions corresponding to the corners. Meanwhile, when the openings have a shape such that the corners thereof are chamfered as described above, color distribution can be uniform.

[0023]

In addition, in the liquid crystal device according to the above-described first to fourth aspects of this invention, the planner shape of opening formed in the light reflecting film may have, for example, a rectangular shape, an oval shape, or an elliptical shape. The elliptical shape can be considered as a shape in which the rectangle-shaped corners are curved. The oval shape is a shape excluding the elliptical shape that can also be obtained by curving the rectangle-shaped corners. When the openings are formed in the above-described shapes, color display can be made more uniform compared with the case in which the openings are simply formed in a square shape.

[0024]

In addition, in the liquid crystal device according to the above-described first to fourth aspects of this invention, the area of a single opening is 5% to 30%, preferably about 20% of the area of one divided section. When the aperture ratio is within the above-described range, satisfactory visibility can be ensured in both the reflective display mode and the transmissive display mode. When the aperture ratio is larger than the above-described range, display becomes unclear since a sufficient amount of reflected light cannot be obtained. When the aperture ratio is smaller than the above-described range, display becomes unclear since illumination effects cannot be sufficiently obtained by an illuminating device.

(5) According to a first manufacturing method for a liquid crystal device of this invention, in which liquid crystal is sandwiched between a pair of substrates, at least one of

which includes a color filter, comprises the steps of forming a light reflecting film on one of the substrates; forming a partitioning member which divides the surface of the substrate into a plurality of sections; and forming subpixels in the plurality of sections divided by the partitioning member. The step of forming the subpixels includes the step of ejecting, in the form of drops, a material for forming the subpixels from nozzles toward the sections and the step of forming the light reflecting film includes the step of forming openings in the light reflecting film at regions corresponding to the sections.

[0025]

In the first manufacturing method for a liquid crystal device, each subpixel is formed by the ink jet method. Thus, the relationship between the openings formed in the light reflecting film and the subpixels can be individually adjusted, so the colors displayed by the subpixels can be finely adjusted. Accordingly, displayed colors can be uniform in a plan manner.

[0026]

In the first manufacturing method for a liquid crystal device, the openings are formed in the light reflecting film at regions corresponding to thickest parts of the subpixels in the step of forming the light reflecting film. According to the liquid crystal device manufactured by this manufacturing method, light that is transmitted through the subpixels once at the thickest parts thereof is used in the transmissive display mode, and light that is transmitted through the subpixels twice at thin parts thereof is used in the reflective display mode.

Accordingly, the optical film thickness in the reflective display mode and the transmissive display mode can be made closer or approximately the same, so color display can be made uniform between the reflective display mode and the transmissive display mode.

[0027]

In addition, in the first manufacturing method for a liquid crystal device, the openings are preferably formed in the light reflecting film at regions corresponding to central parts of the plurality of sections in the step of forming the light reflecting film. As shown in Figs. 5(a) and (c), when the subpixels 16 are formed by the ink jet method, the subpixels 16 tend to be projected at central regions of the sections divided by the partitioning member 14. Accordingly, when the openings 18 are formed in the light reflecting film 9 at regions corresponding to the central parts, the optical film thickness in the reflective display mode and the transmissive display mode can be made close or approximately the same. Thus, color display can be made uniform between the reflective display mode and the transmissive display mode.

[0028]

In addition, in the first manufacturing method for a liquid crystal device, the surface of the substrate may be divided into a plurality of rectangular sections in the step of forming the partitioning member. In such a case, the openings are preferably formed in the light reflecting film in such a manner that the openings extend in the longitudinal direction of the rectangular sections in the step of forming the light reflecting film. Accordingly, in the transmissive display mode, a sufficient amount of light that is uniform in the longitudinal direction of the subpixels can be supplied to the subpixels, so uniform color display can be realized.

[0029]

In addition, in the first manufacturing method for a liquid crystal device, the openings are preferably formed in the light reflecting film in such a manner that the openings have a shape corresponding to the thickness of the subpixels in the step of forming the light reflecting film. In color display, color density is significantly affected by the thickness of the subpixels. Thus, uniformity of color density is degraded when the openings are formed regardless of the thickness of the subpixels. In contrast, uniform color display can be obtained when the shape of the openings is determined based on thickness of the subpixels.

[0030]

In addition, in the first manufacturing method for a liquid crystal device, the openings having a shape such that the corners thereof are chamfered are preferably formed in the light reflecting film in the step of forming the light reflecting film. In general, the subpixels formed in sections divided by the partitioning member tend to have a convex shape such that the central parts thereof are thick and the peripheral parts thereof are thin. In addition, there are cases that the surfaces of the subpixels along the diagonal lines of the sections are three-dimensionally curved. In such a case, when the corners of the openings formed in the light reflecting film are set to be an angular shape of, for example, 90°, uniformity of color may be degraded at the portions corresponding to the corners. In contrast, when the openings have a shape such that the corners thereof are chamfered as described above, uniform color distribution can be obtained.

[0031]

In addition, in the first manufacturing method for a liquid crystal device, the planner shape of the opening having a rectangular shape, an oval shape, or an elliptical shape are preferably formed in the light reflecting film in the step of forming the light reflecting film. Here, the elliptical shape is a specified shape in which the corners of a rectangle shape is curved. The oval shape is a shape excluding the elliptical shape that can also be obtained by curving the corners of a rectangle shape. When the openings are formed in one of the above-described shapes, color display can be made more uniform compared with the case in which the openings are simply formed in a square shape.

[0032]

In addition, in the first manufacturing method for a liquid crystal device, the openings are preferably formed in the light reflecting film in such a manner that the area of a single opening is 5% to 30%, preferably about 20% of the area of a single section in the step of forming the light reflecting film. When the aperture ratio is within the above-described range, satisfactory visibility can be ensured in both the reflective display mode and the transmissive display mode. When the aperture ratio is larger than the above-described range, display becomes unclear since a sufficient amount of reflected light cannot be obtained. When the aperture ratio is smaller than the above-described range, the display becomes unclear since sufficient illumination effects cannot be obtained by an illuminating device.

[0033]

[Description of the Embodiments]

This invention will be explained below in conjunction with embodiments. Fig. 1 is an exploded view showing an embodiment of a liquid crystal device according to this invention, and Fig. 2 is a cross-sectional view of the liquid crystal device shown in Fig. 1 cut along line I-I. A liquid crystal device 1 of this embodiment is an active matrix liquid crystal device using Thin Film Diodes (TFDs), which are two-terminal switching elements, as active elements. In addition, the liquid crystal device 1 is also a transflective liquid crystal device having both functions of reflective display and transmissive display, and a Chip On Glass (COG) type liquid crystal device in which an IC chip is directly mounted on a substrate.

[0034]

With reference to Fig. 1, a liquid crystal panel 2 is formed by laminating a first substrate 3a and a second substrate 3b with an annular sealing member 4. Then, liquid crystal L is injected into a gap, that is, a so-called cell gap, formed between the first and second substrates 3a and 3b. Then, liquid crystal driving ICs 6a and 6b are mounted on the first and second substrates 3a and 3b, respectively, and an illuminating device 7 is disposed at the side opposite to the observer's side, that is, outside the first substrate 3a in this embodiment, as a backlight. The liquid crystal device 1 is thus constructed.

[0035]

The liquid crystal driving ICs 6a and 6b are mounted using, for example, Anisotropic Conductive Films (ACFs). In addition, liquid crystal L is injected into the cell gap through an opening 4a formed in the sealing member 4 at a suitable position for filling the liquid crystal L into the cell gap. After the liquid crystal L is injected, the opening 4a is sealed by a resin, etc.

[0036]

As shown in Fig. 2, the first substrate 3a includes a first base plate 8a formed of glass, plastic, etc., having a rectangular shape when seen from the arrow B direction. In addition, a light reflecting film 9, a color filter 11, first electrodes 12a, and an orientation film 13a are formed on the inside surface of the first base plate 8a (the upper side in Fig. 2), in that order. In addition, a polarizing plate 19a is mounted on the outside surface of the first base plate 8a by adhesive or the like.

[0037]

As shown in Fig. 5(a), the color filter 11 includes a bank 14 which is formed on the light reflecting film 9 in a grid-shaped pattern as seen from the arrow C direction and which serves as a partitioning member; a plurality of grid subpixels 16 which are individually disposed in the plurality of grid sections formed by the bank 14; and protecting films 17 which are individually formed on the subpixels 16. In this embodiment, the subpixels 16 and the protecting films 17 are both formed by an ink jet method, which will be described later.

[0038]

Fig. 5 **[Figs. 5(a), (b), and (c)]** shows enlarged views of only some of the plurality of subpixels 16 (substantially three), the color filter 11 is formed such that a large number of subpixels 16 are arranged in the longitudinal and lateral directions to form a matrix pattern when seen from the arrow C direction. Each of the plurality of subpixels 16 functions as a dot for displaying an individual color, and a group consisting of three subpixels (a red subpixel 16R, a green subpixel 16G, and a blue subpixel 16B) form a single pixel.

[0039]

As shown in Fig. 5(a) and Fig. 5(c), which are cross-sectional views of the subpixels 16, each of the subpixels 16 is formed in a convex shape in which the highest part is at the center P, in other words, shaped like a dome. It is considered that this shape is naturally formed when the subpixels 16 are formed by the ink jet method, that is, when a subpixel material is ejected toward the sections in the form of drops.

[0040]

The subpixels 16 can be divided into red subpixels 16R, green subpixels 16G, and blue subpixels 16B, and are arranged in, for example, a striped pattern (Fig. 4 (a)), a mosaic pattern (Fig. 4 (b)), a delta pattern (Fig. 4 (c)), etc. In the striped pattern, subpixels 16 of the same color are vertically arranged in a matrix. In the mosaic pattern, three arbitrary subpixels 16 correspond to R, G, and B both in the longitudinal and lateral directions. In the delta pattern, the subpixels 16 are arranged in a staggered manner such that three adjacent subpixels correspond to R, G, and B.

[0041]

In Fig. 5 (a), in this embodiment, the bank 14 is formed by applying a non-transparent resin by an arbitrary coating method, for example, spin coating, and forming a pattern by an arbitrary patterning method, for example, photolithographic method. Since the bank 14 is formed of a non-transparent resin, the bank 14 also functions as a black mask which suppresses light from leaking from the color filter 11. Of course, an additional black mask may also be disposed under the bank 14.

[0042]

The protecting films 17 are normally formed of a transparent resin material, and function, for example, as follows. First, the surface of the color filter substrate can be flattened by forming the protecting films 17, so electrodes can be prevented from being cut when forming the electrodes on the surface of the color filter substrate. Second, the resistance of the electrodes on the protecting films 17 is reduced, so the contrast ratio between the pixels is increased. Third, the protecting films 17 serve as protectors; more specifically, the protecting films 17 prevent the pixels formed in the color filter substrate from being damaged in the processes after the protecting films 17 are formed. Fourth, when the color filter substrate is used for the liquid crystal device, and liquid crystal is injected into the cell gap, the protecting films 17 prevent impurities from being diffused into the liquid crystal.

[0043]

In Fig. 1, the light reflecting film 9 is formed by applying a light reflecting metal material such as Al, etc., and alloys thereof, at a uniform thickness by an arbitrary deposition method, for example, sputtering method, and then forming a pattern by an arbitrary patterning method, for example, photolithographic method. In the patterning process, openings 18 are formed in the light reflecting film 9 at regions for forming the subpixels 16, that is, corresponding to the individual sections formed by the bank 14.

[0044]

As shown in Figs. 5(a)-(c), in this embodiment, the openings 18 are individually formed at central regions P of the sections formed by the bank 14, that is, regions corresponding to the thickest film parts of the subpixels 16 formed by the sections. In addition, as shown in Fig. 5 (b), in this embodiment, each of the openings 18 is formed in a rectangular shape that extends in the longitudinal direction of each subpixel 16.

[0045]

In Fig. 2, the first electrodes 12a are formed in a striped pattern when seen from the arrow B direction. In Figs. 1 and 2, a small number of first electrodes 12a with broad gaps therebetween are shown in order to facilitate the understanding of the pattern of the first electrodes 12a; however, in practice, a large number of first electrodes 12a are formed with extremely narrow gaps therebetween. The first electrodes 12a are formed by applying, for example, Indium Tin Oxide (ITO) at a uniform thickness by an arbitrary deposition method, for example, sputtering method, and then forming a desired pattern such as a striped pattern, etc., by an arbitrary patterning method, for example, photolithographic method.

[0046]

In Fig. 1, the first electrodes 12a are formed so as to extend beyond the sealing member 4, so the first electrodes 12a can be conductively connected to output bumps, that is, output terminals, of the liquid crystal driving IC 6a. The liquid crystal driving IC 6a supplies scanning signals or data signals to the first electrodes 12a.

[0047]

The orientation film 13a is formed by, for example, applying a polyimide solution and then baking it. The orientation film 13a is subject to an orientation process, for example, a rubbing process, which determines the orientation in the vicinity of the surface of the first substrate 3a of liquid crystal molecules in the liquid crystal L.

[0048]

In Fig. 1, the second substrate 3b includes a second base plate 8b formed of glass, plastic, etc., having a rectangular shape, and a plurality of second electrodes 12b in dot are formed on the inside surface of the second base plate 8b (the lower side of Fig. 1) in a matrix pattern. In Fig. 1, the second electrodes 12b are schematically shown in large dot in order to facilitate the understanding thereof. However, in practice, a large number of extremely small second electrodes 12b are formed.

[0049]

Fig. 3 is an enlarged view of a part of the second substrate 3b shown by the arrow D. As shown in Fig. 3, an electrical line 21, TFD units 22 which extend from the electrical line 21 and which function as switching elements, and second electrodes 12b which are connected to the electrical line 21 via the TFD units 22 are formed on the inside surface of the second base plate 8b. As shown in Fig. 1, the second electrodes 12b are arranged in a dot-matrix pattern as already described before.

[0050]

Processes for forming the above-described components will be described below. that is, a first layer 21a of the electrical line 21 and first metal films 22a of the TFD units 22 are formed by applying, for example, tantalum (Ta) at a uniform thickness by sputtering method. Then, by performing an anodizing process, a second layer 21b is formed on the first layer 21a of the electrical line 21, and insulating films 22b are formed on the first metal films 22a of the TFD units 22. Then, for example, after chromium (Cr) is uniformly formed by sputtering method, a third layer 21c is formed on the second layer 21b of the electrical line 21 by patterning, and second metal films 22c are formed on the insulating films 22b of the TFD units 22. There are two types of second metal films 22c: one type is the second metal film 22c which extends from the electrical line 21 and overlaps the insulating films 22b of the TFD units 22, and another kind is the second metal film 22c which connects the insulating films 22b and the second electrodes 12b.

[0051]

Accordingly, each of the TFD units 22 includes a first TFD element 23a at the side close to the electrical line 21 and a second TFD element 23b at the side close to the second electrodes 12b. The first TFD element 23a has a Metal-Insulator-Metal (MIM) structure in which the second metal film 22c, the insulating film 22b, and the first metal film 22a are laminated, in this order, when seen from the electrical line 21 side. In addition, the second TFD element 23b has a Metal-Insulator-Metal (MIM) structure in which the first metal film 22c, the insulating film 22b, and the second metal film 22c are laminated, in this order, when seen from the electrical line 21 side.

[0052]

This TFD structure, in which two TFD elements are serially connected in an electrically reversed manner, is called a "back-to-back" structure, and is used to obtain stable switching characteristics of the MIM elements. When the required stability of the switching characteristics is not very high, a TFD unit composed of a single TFD element may also be used in place of the back-to-back structure.

[0053]

The second electrodes 12b connected to the second metal films 22c of the second TFD elements 23b are formed by applying, for example, ITO, at a uniform thickness by an arbitrary deposition method, for example, sputtering method, and then forming a pattern by an arbitrary patterning method, for example, photolithographic method. In Fig. 1, the first electrodes 12a are arranged on the first substrate 3a, which opposes the second substrate 3a, in a direction such that the first electrodes 12a cross the electrical line 21 shown in Fig. 3, for example, in the direction perpendicular to the electrical line 21.

[0054]

In Fig. 2, an orientation film 13b is formed on the second electrodes 12b. Although the second electrodes 12b having a relatively large size are schematically shown in Fig. 2 in order to facilitate the understanding thereof, in practice, a large number of extremely small second electrodes 12b are formed. The orientation film 13b is formed by, for example, applying a polyimide solution and baking it. The orientation film 13b is subject to an orientation process, for example, a rubbing process, which determines the orientation in the vicinity of the surface of the second substrate 3b of the liquid crystal molecules in the liquid crystal L.

[0055]

A polarizing plate 19b is mounted on the outside surface of the second base plate 8b by adhesion or the like. The polarizing plate 19b is mounted so that the polarization axis thereof is shifted only for a predetermined angle with respect to the polarization axis of the polarizing plate 19a on the first substrate 3a side.

[0056]

In Fig. 1, the electrical lines 21 are formed on the second substrate 3b so as to extend beyond the sealing member 4, so that the electrical lines 21 can be conductively connected to output bumps, that is, output terminals, of the liquid crystal driving IC 6b. The liquid crystal driving IC 6b supplies the signal to be supplied to the first electrodes 12a among the scanning and data signals and another signal to one line of the switching units 22 **[22 is described as "TFD units" in [0062]]** according to the electrical line 21.

[0057]

In Fig. 1, the illuminating device 7, disposed at the rear side of the first substrate 3a, that is, the side opposite to the observer's side includes a conductive body 24 and a plurality of (for example, three) LEDs 26, which serve as light sources. The conductive body 24 has approximately the same area as the first substrate 3a, and the LEDs 26 are disposed such that the LEDs 26 oppose a light entrance port 24a, which is one of the side surfaces of the conductive body 24. The conductive body 24 is formed of, e.g., acrylic resin, polycarbonate resin, glass, etc. Light incident from the light entrance port 24a is transmitted, emitted from a light exit surface 24b facing the liquid crystal panel 2, and supplied to the liquid crystal panel 2.

[0058]

In Fig. 2, the first substrate 3a and the second substrate 3b are attached by the sealing member 4. At the same time, the cell gap is maintained by grain-shaped spacers 27 which are dispersed over one of the first and second substrates 3a and 3b, and the liquid crystal L is injected into the cell gap. For example, twisted nematic (TN) liquid crystal is used as the liquid crystal L.

[0059]

The liquid crystal device 1 of this embodiment is thus constituted. When the liquid crystal device 1 serves as a reflective liquid crystal device, external light incident from the outside of the first substrate 3b of an observer in Fig. 2, such as sunlight, room light, etc., is transmitted through the liquid crystal L, is reflected at the light reflecting film 9, and is again supplied to the liquid crystal L.

[0060]

When the liquid crystal device 1 serves as a transmissive liquid crystal device, light is emitted from the LEDs 26, which are included in the illuminating device 7, is taken from the light entrance surface 24a of the conductive body 24, and is uniformly emitted from the light exit surface 24b. Then, the emitted light goes through the openings 18 formed in the light reflecting film 9, and is supplied to the liquid crystal L.

[0061]

In both the reflective display and the transmissive display, voltages are applied between the first electrodes 12a which sandwich the liquid crystal L and the second electrodes 12b, which oppose the first electrodes 12a, in accordance with switching operations of the switching units 22. Thus, the orientation of the liquid crystal molecules within the liquid crystal L is controlled. Because of the orientation control, light supplied to the liquid crystal L is modulated, the modulated light reaches the polarizing plate 19, and an image is displayed on the observer's side by the polarized light which goes through the polarizing plate 19b and the polarized light which does not go through the polarizing plate 19b. At this time, a desired color is displayed by selecting the reflective light which went through one of R, G, and B of the color filter 11.

[0062]

In this embodiment, as shown in Figs. 5(a)-(c), the openings 18 are formed in the light reflecting film 9 at regions corresponding to the thickest film parts of the subpixels 16. Thus, in the reflective display mode, as shown by the arrow X0, light that goes through the subpixels 16 to and from the light reflecting film 9 at parts excluding the thickest film parts of the subpixels 16, is used for color display. Meanwhile, in the transmissive display mode, as shown by the arrow X1, light that goes through the subpixels 16 at the thickest film parts thereof is used for color display.

[0063]

Accordingly, light going through the subpixels 16 once at the thickest film parts thereof is used in the transmissive display mode, and light going through the subpixels 16 twice at relatively thin film parts thereof is used in the reflective display mode. Accordingly, the optical film thickness in the reflective display mode and in the transmissive display mode can be made close or approximately the same, so color display can be made uniform between the reflective display mode and the transmissive display mode.

[0064]

As shown in Figs. 5(a) and (c), when the subpixels 16 are formed by the ink jet method (which will be described later in detail) according to this embodiment, the subpixels 16 tend to be projected at the central regions of the sections formed by the bank 14. Accordingly, when the openings 18 are formed in the light reflecting film 9 at regions corresponding to the central parts of the sections in this embodiment, the optical film thickness in the reflective display mode and in the transmissive display mode can be made close or approximately the same. Thus, uniform color can be displayed between the reflective display mode and the transmissive display mode.

[0065]

In addition, in this embodiment, as shown in Figs. 5(a)-(c), a plurality of rectangular sections are formed by the bank 14 and the subpixels 16 are individually formed in the rectangular sections. In addition, the openings 18 of the light reflecting film 9 have a rectangular shape that extends in the longitudinal direction of the rectangular sections. Because of this structure, in the transmissive display mode, sufficient amount of light that is uniform in the longitudinal direction of the subpixels 16 can be supplied, so uniform color display can be realized.

[0066]

Fig. 6 shows a modification of the openings 18 formed in the light reflecting film 9. Here, the openings 18 are the same as the openings 18 shown in Fig. 5 according to the previous embodiment except that four corners of the openings 18 have linear chamfers M1. Other points are the same as in the case of the embodiment shown in Fig. 5. A method of forming the linear chamfers M1 in the corners of the opening 18 can be accomplished by patterning, which uses a photomask provided with an exposure opening pattern having the above-mentioned chamfers M1, for example, when patterning is performed onto the light reflecting film 9 by an arbitrary patterning method, e.g., a photolithographic method.

[0067]

Since the corners of the openings 18 having the linear chamfers M1 are formed, light can be supplied in accordance with the three-dimensional curves of the subpixels 16, which appear along the diagonal lines of sections divided by the bank 14. Accordingly, uniform color display can be realized.

[0068]

Fig. 7 shows another modification of the openings 18 formed in the light reflecting film 9. The openings 18 shown in Fig. 7 are the same as the openings 18 shown in Fig. 5 according to the previous embodiment except that curved chamfers M2 are formed in the four corners of the openings 18. Other points are the same as in the case of the embodiment shown in Fig. 5. In the same manner as the case of the embodiment shown in Fig. 6, for example, when patterning is formed onto the light reflecting film 9 by an arbitrary method, e.g., a photographic method, a method of forming the curved chamfers M2 in the corners of the opening 18 can be accomplished by patterning, which uses a photomask provided with an exposure opening pattern having the above-mentioned chamfers M2.

[0069]

Similarly to the modification shown in Fig. 6, since the above-mentioned chamfers M2 are arranged in the corners of the opening 18, light can be supplied in accordance with the three-dimensional curves of the subpixels 16, which appear along the diagonal lines of sections divided by the bank 14. Accordingly, uniform color display can be realized.

[0070]

The planar shape of the openings 18 formed in the light reflecting film 9 corresponding to the subpixels 16 may also have a flat oval shape which can be obtained by variously changing the dimension of the chamfers M2 shown in Fig. 7(b) or an elliptical shape other than the rectangle shape shown in Fig. 5(b), the rectangle shape with linear chamfers M1 shown in Fig. 6(b), and the rectangle shape with curved chamfers M2 shown in Fig. 7(b).

[0071]

Fig. 8 is a diagram showing another example of a method for determining a flat shape of the openings 18 shown in Fig. 5. This method will be described below.

[0072]

As described in this embodiment, when the subpixels are formed by supplying ink, i.e., a subpixel material to the sections divided by the bank 14 based on the ink jet method, the thickness of the subpixels may not be necessarily constant within the plane. For example, as shown in Figs. 5(a) and (c), the subpixels may be formed in a convex shape, i.e., a shape like a dome. When the thickness of the subpixels 16 is not uniform within the plane, for example, the openings 18 are preferably formed in only regions of the light reflecting film 9 corresponding to the parts where the thickness of the subpixels 16 is larger than a reference value T0. Accordingly, color display during the reflective display mode and the transmissive display mode can be made more uniform.

[0073]

Thus, the shapes of the openings 18 are formed in the light reflecting film 9 in the shape corresponding to the thickness of the subpixels 16, the shape of the openings is effectively determined by using optical interference fringes. More specifically, as shown in Fig. 8(a), natural light R0 is irradiated to the subpixel 16, and light reflected form the light reflecting film 9 is shot by a camera 30. Then, when the shot image is displayed on a screen or the like, interference fringes F, which are schematically shown in Fig. 8(b), are obtained in accordance with the thickness difference of the subpixel 16. The interference fringes F can be regarded as contour lines of the surface of the subpixel 16. Accordingly, when the openings are formed in the light reflecting film 9 by selecting desired one of the interference fringes F in accordance with the interference fringes F, the openings 18 that accurately matches the thickness of the subpixels 16 can be obtained.

[0074]

Thus, the aperture ratio of the various openings 18 is set in the range of 5% to 30%, and is preferably set to 20%. The aperture ratio is the area of the sections divided by the bank 14, i.e., the ratio of the area of the opening 18 for the plane area of individual subpixel 16.

[0075]

When the aperture ratio is within the above-described range, satisfactory visibility can be ensured in both the reflective display mode and the transmissive display mode. When the aperture ratio is larger than the above-described range, display becomes unclear since a sufficient amount of reflected light cannot be obtained. When the aperture ratio is smaller than the above-described range, the display becomes unclear since sufficient illumination effects cannot be obtained by an illuminating device.

Fig. 9 shows an embodiment of a manufacturing method for the liquid crystal device 1 shown in Fig. 1. In this manufacturing method, P1 to P7 are processes for forming the first substrate 3a, and P11 to P14 are processes for forming the second substrate 3b. Normally, the processes for forming the first substrate 3a and the processes for forming the second substrate 3b are individually performed. In this embodiment, the first substrate 3a and the second substrate 3b having the size shown in Fig. 1 are not directly formed. As shown in Figs. 10(a) and (b), a first mother substrate 33a having the size of a plurality of first substrates 3a and a second mother substrate 33b having the size of a plurality of second substrates 3b are formed.

Ultimately, the first and second substrates 3a and 3b are individually manufactured by cutting the mother substrates 33a and 33b, respectively.

[0076]

In Fig. 9, a first substrate formation process will be described below. First, a plurality of light reflecting films 9 of a liquid crystal panel 2 is formed by a photolithographic method or the like (P1) on the surface of a first mother base plate 38a (see Fig. 10(a)) of a large area formed of a transparent glass, a transparent plastic, etc. Then, the color filters 11 are formed on the light reflecting films 9 by the ink jet method or the like, which will be described later (P2), and then the first electrodes 12a are formed by a photolithographic method or the like (P3).

[0077]

Then, the orientation films 13a are formed on the first electrodes 12a by coating, printing, etc. (P4), and then the orientation films 13a are subject to an orientation process, for example, a rubbing process, which determines the initial orientation of the liquid crystal (P5). Next, the sealing members 4 are formed in an annular shape in the surrounding portions of the respective liquid crystal panel regions by, e.g., screen printing, etc. (P6), and then spherical-shaped spacers 27 are dispersed thereon (P7). Accordingly, the first mother substrate 33a (see Fig. 10(a)) of a large area having a plurality of panel patterns on the first substrates 3a of the liquid crystal panel 2 is formed.

[0078]

A second substrate formation process (P11-P14 of Fig. 9) is performed separately from the above-described first substrate formation process. Specifically, first, a second mother base plate 38b (see Fig. 10(b)) of a large area formed of a transparent glass, a transparent plastic, etc., is prepared. Then, the electrical lines 21 and the switching elements 22 shown in Fig. 3 for a plurality of the liquid crystal panel 2 are formed on the surface of the second mother base plate 38b (P11), and then the second electrodes 12b in a dot shape are formed with ITO, etc., by a photolithographic method or the like (P12).

[0079]

Next, the orientation films 13b (see Fig. 2) are formed by coating, printing, etc. (P13), and then the orientation films 13b are subject to an orientation process, for example, a rubbing process, which determines the initial orientation of the liquid crystal (P14). Accordingly, the second mother substrate 33b of a large area having a plurality of panel patterns on second substrates 3b of the liquid crystal panel 2 is formed.

[0080]

Thus, after the first mother substrate 33a and the second mother substrate 33b of a large area are formed, the mother substrates are aligned by sandwiching the sealing member 4 therebetween, that is, positioning is performed and then attachment is performed (P21). Accordingly, a vacant panel structural body is formed in a state in which panel portions for a plurality of liquid crystal panels are included and liquid crystal is not yet injected.

[0081]

Next, the completed vacant panel structural body is cut, and a so-called strip-shaped vacant panel structural body is formed in a state in which the liquid crystal injection openings 4a (see Fig. 1) of the sealing member 4 for the respective liquid crystal panel portions are exposed to the outside (P22). Then, the liquid crystal L is injected to the inside of the respective liquid crystal panel portions through the exposed liquid crystal injection openings 4a, and then the respective liquid crystal injection openings 4a are sealed by a resin, etc. (P23).

[0082]

Generally, in the liquid crystal injection process, for example, a container is filled with liquid crystal and the container filled with liquid crystal and strip-shaped vacant panel pieces are put into a chamber or the like. Then, the chamber or the like is made into a vacuum state, and the strip-shaped vacant panel pieces are soaked into the liquid crystal inside of the chamber. Then, the chamber is released to an atmospheric pressure. Since the inside of the vacant liquid crystal panels are in a vacuum state at this time, the liquid crystal to be pressured by an atmospheric pressure is introduced to the inside of the liquid crystal panels through the liquid crystal injection openings. Since the liquid crystal adheres to the exterior surfaces of the liquid crystal panel structural body after liquid crystal is injected, a cleaning process is performed onto the strip-shaped panel pieces in P24 after the liquid crystal injection process.

[0083]

Then, after the liquid crystal injection and cleaning are performed, strip-shaped mother panel pieces are subject to a scribing process, i.e., a cutting process, so a plurality of liquid crystal panels 2 are obtained (P25). Thus, as shown in Fig. 1, the liquid crystal driving ICs 6a and 6b are mounted to each of the liquid crystal panels 2 which was thus manufactured, and the illuminating device 7 is mounted as a backlight (P26). In addition, the polarizing plate 19a is mounted to the outside surface of the first substrate 3a, and the polarizing plate 19b is mounted to the outside surface of the second substrate 3b (P27). The liquid crystal device 1 to be accomplished is thus completed.

[0084]

The color filter formation process P2 in the first substrate formation process of Fig. 9 will be described in detail.

[0085]

Fig. 11 schematically shows a process order for a manufacturing method of the color filter 11. First, as seen from the arrow B direction, the bank 14 is formed of a non-transparent resin material in a grid-shaped pattern on the surface of the mother base plate 38a formed of glass, plastic, etc., on which the light reflecting film 9 is formed (P31). The portions 28 of grid holes of a grid-shaped pattern is a section where the subpixels 16 are formed, i.e., subpixel formation section.

[0086]

The plane dimension of individual subpixel formation section 28 formed by the bank 14 is, for example, approximately 30 μm × 100 μm when seen from the arrow B direction. The bank 14 is preferably formed by applying an ink-repellent resin at a predetermined uniform thickness by an arbitrary deposition method, for example, spin coating method, and forming a predetermined grid shape by a suitable patterning method, for example, photolithographic method.

[0087]

Then, in P32, red, green, and blue subpixels 16 are formed in the sections formed by the bank 14 by the ink jet method. Specifically, an ink jet head 52 scans the surface of the mother base plate 38a, and a subpixel material M6 is ejected from nozzles 57 arranged in the ink jet head 52, in the form of ink drops at a predetermined timing corresponding to one of the arrangement patterns shown in Fig. 4 and adheres onto the mother base plate 38a. Then, the subpixel material M6 is solidified by baking process or ultraviolet ray irradiation process, thus forming the subpixels 16. The above-described processes are repeated for each of the red, green, and blue subpixels 16R, 16G, and 16B, so a desired arrangement subpixel pattern is formed.

[0088]

Then, in P33, the protecting films 17 are individually formed on the subpixels 16 in the sections formed by the bank 14 by the ink jet method. Specifically, similarly to the processes for forming the subpixels 16, the ink jet head 52 scans the surface of the mother base plate 38a, and a protecting film material M7 is ejected from the nozzles 57 arranged in the ink jet head 52 toward the subpixels 16 in the form of ink drops at a predetermined timing corresponding to one of the arrangement patterns shown in Fig. 4 and adheres onto the subpixels 16 on the mother base plate 38a. Then, the protecting film material M7 is solidified by, e.g., baking process for approximately 30 to 60 minutes at 200°C, thus forming the protecting films 17.

[0089]

In the ink jet process of the subpixel formation process P32, scanning of the ink jet head 52 for the R, G, and B subpixels 16 is repeated, and the subpixels are formed. Alternatively, the ink jet head 52 may be provided with nozzles for the respective three colors (R, G, and B), so the R, G, and B can be simultaneously formed by one scanning.

[0090]

Meanwhile, in the ink jet process of the protecting film formation process P33, a predetermined amount of ink drops is supplied to a plurality of all grid holes formed by the bank 14 during one scanning period of the ink jet head 52. However, when the thickness of the subpixels 16 formed in the grid-shaped holes is different depending on R, G, and B, the ink amount ejected from the nozzles 57 is appropriately adjusted in accordance with the colors.

[0091]

The ink jet head 52 used for the subpixel formation process P32 and the ink jet head 52 used for the protecting film formation process P33 can be replaced with the same type of ink jet device and mounted. Alternatively, the ink jet head 52 used for the subpixel formation process P32 and the ink jet head 52 used for the protecting film formation process P33 can be mounted to separate ink jet devices, which are separately operated. In addition, depending on the case, a method can also be used in which the same thing is used for the ink jet head 52 and the ink jet device which mounts it, and ink to be supplied to the same ink jet head 52 is exchanged between the subpixel material and the protecting film material.

[0092]

In addition, the scanning method the mother base plate 38a by the ink jet head 52 in the subpixel formation process P32 and the protecting film formation process P33 is not limited to a special method, but various methods can be considered. For example, a method is considered in which a plurality of nozzles 57 may be arranged in a line having substantially the same length as one side of the mother base plate 38a, and the nozzle lines are formed, and the subpixel material M6 and the protecting film material M7 are supplied to the entire surface of the mother base plate 38a by one scanning. Another method is also considered in which main scanning for emitting ink to the ink jet head 52 having a nozzle line whose length is shorter than one side of the mother base plate 38a and sub-scanning for shifting a main scanning position are repeated, and ink is supplied to the entire surface of the mother base plate 38a.

[0093]

Fig. 12 shows an embodiment of an ink jet device which is an example of a device for implementing the subpixel formation process P32 and the protecting film formation process P33. This ink jet device 46 is a device used for ejecting and attaching ink drops of the subpixel material or the protecting film material onto the mother base plate 38a (see Fig. 10(a)) at predetermined positions in the respective substrate sections 3a.

[0094]

In Fig. 12, the ink jet device 46 is provided with a head unit 56 having the ink jet head 52; a head position control device 47 which controls the position of the ink jet head 52; a substrate position control device 48 which controls the position of the mother base plate 38a; a main scanning drive device 49 which moves the ink jet head 52 relative to the mother base plate 38a in a main scanning direction; a sub-scanning drive device 51 which moves the ink jet head 52 relative to the mother base plate 38a in a sub-scanning direction; a substrate supply device 53 which supplies the mother base plate 38a to a predetermined operation position in the ink jet device 46; and a control device 54 which manages the general control of the ink jet device 46.

[0095]

The head position control device 47, the substrate position control device 48, the main scanning drive device 49, and the sub-scanning drive device 51 are disposed on a base 39. In addition, a cover 34 may cover the above-described devices, as needed.

[0096]

For example, as shown in Fig. 14, the ink jet head 52 includes a plurality of head portions 50 (in this embodiment, six), and a carriage 55 which retains, as a support means, the head portions 50 such that the head portions 50 are aligned. The carriage 55 is provided with holes, that is, concave portions, which are slightly larger than the head portions 50, at positions to support the head portions 50. The respective head portions 50 are inserted into the holes, and fixed by screws, adhesives, or other fixing means. Additionally, if the positions of the head portions 50 relative to the carriage 55 are accurately determined, the head portions 50 may also be fixed by simple press fitting without using a special fixing means.

[0097]

As shown in Fig. 14(b), the head portions 50 include nozzle lines 58 in which a plurality of nozzles 57 are aligned. The number of the nozzles 57 is, for example, 180, and the hole diameter of each nozzle 57 is, for example, 28 μm. The nozzle pitch between the nozzles 57 is, for example, 141 μm. In Fig. 14(a), symbol X denotes a main scanning direction, and symbol Y denotes a sub-scanning direction of the ink jet head 52.

[0098]

The ink jet head 52 main-scans the mother base plate 38a by being parallel-moved to the X direction. During this main scanning, the subpixel material or the protecting film material as ink is selectively ejected from a plurality of nozzles 57 within the respective head portions 50. Thus, the subpixel material or the protecting film material adheres to predetermined positions within the mother base plate 38a. Furthermore, the ink jet head 52 parallel-moves, for example, only the length L0 of one line portion of the nozzle lines 58 or the integral multiple at a predetermined distance in the sub-scanning direction Y, so the main scanning position by the ink jet head 52 can be shifted at a predetermined interval.

[0099]

The nozzle lines 58 are formed in the head portions 50 in such a manner that the nozzle lines 58 are all arranged on a line Z when the respective head portions 50 are mounted to the carriage 55. A distance D between the respective adjacent head portions 50 is determined such that the distance between nozzles 57 at the far end positions to which the pair of adjacent head portions 50 belongs becomes equal to the length L0 of the nozzle lines 58 in the head portions 50. The nozzle lines 58 are thus arranged for easily facilitating the movement control of the ink jet head 52 in the main scanning direction X and in the sub-scanning direction Y. The arrangement of the nozzle lines 58, that is, the arrangement of the head portions 50 relative to the carriage 55 can be arbitrarily set other than the above-described arrangement.

[0100]

For example, Figs. 16(a) and (b) show the internal structure of each of the head portions 50. Specifically, the head portion 50 is provided with a nozzle plate 59 formed of, e.g., stainless steel, a vibrating plate 61 which opposes the nozzle plate 59, and a plurality of partitioning members 62 which attaches the nozzle plate 59 and the vibrating plate 61. Between the nozzle plate 59 and the vibrating plate 61, a plurality of ink chambers 63 and an ink pool 64 are formed by the partitioning members 62. The plurality of ink chambers 63 and the ink pool 64 are connected to each other via a route 68.

[0101]

The vibrating plate 61 is provided with an ink supply hole 66 at a suitable position, and an ink supply device 67 is connected to the ink supply hole 66. The ink supply device 67 supplies the subpixel material M or the protecting film material M to the ink supply hole 66. The subpixel material M or the protecting film material M which was supplied is filled in the liquid pool 64, and then is filled in the ink chamber 63 via the route 68. With respect to the subpixel material M, one of R, G, and B is supplied from the ink supply device 67, and different head portions 50 are prepared for the respective colors.

[0102]

The subpixel material M is formed by dispersing R, G, and B coloring materials in a solvent. In addition, the protecting film material M is formed of a transparent heat-curable resin or a transparent photocurable resin and includes at least one of, for example, acrylic resin, epoxy resin, imide resin, and fluorocarbon resin. The viscosity of the protecting film material M is preferably set to 4 cps to 50 cps. This is because when the viscosity is lower than 4 cps, the fluidity is too high to form a predetermined shape, and when the viscosity is higher than 50 cps, it is difficult to eject a predetermined amount from the nozzles 57.

[0103]

The nozzle plate 59 is provided with the nozzles 57 for ejecting the subpixel material M or the protecting film material M in a jet shape from the ink chambers 63. In addition, ink pressure member 69 are disposed on the rear surface of the surface in which the ink chambers 63 of the vibrating plate 61 are formed. As shown in Fig. 16(b), each of the ink pressure member 69 includes a piezoelectric element 71 and a pair of electrodes 72a and 72b which sandwich the piezoelectric element 71. The piezoelectric element 71 are flexure- deformed by being energized to the electrodes 72a and 72b so as to be protruded to the outside shown by the arrow C, thereby the capacity of the ink chambers 63 increases. Thus, the subpixel material M or the protecting film material M corresponding to the increased capacity flows into the ink chambers 63 from the ink pool 64 through the route 68.

[0104]

Next, if energizing to the piezoelectric element 71 is removed, the piezoelectric element 71 and the vibrating plate 61 return to the initial shapes, so the capacity of the ink chambers 63 also returns to the initial capacity. By so doing, the ink chambers 63 also return to the original capacity, so the pressure of the subpixel material M or the protecting film material M contained in the ink chambers 63 is increased, and is ejected toward the mother base plate 38a (see Fig. 10(a)) from the nozzle 57 as an ink drop M6, M7. In order to suppress the ink drop M6, M7 from being stuck in the nozzle 57 or being ejected in an undesirable direction, an ink-repellent layer 73 formed of, for example, a Ni-tetrafluoroethylene deposited layer, is arranged around the nozzle 57.

[0105]

In Fig. 13, the head position control device 47 includes an α motor 74 which inplane-rotates the ink jet head 52, a β motor 76 which slidably rotates the ink jet head 52 about an axis parallel to the sub-scanning direction Y, a γ motor 77 which slidably rotates the ink jet head 52 about an axis parallel to the main scanning direction X, and a Z motor 78 which parallel-moves the ink jet head 52 in the vertical direction.

[0106]

In Fig. 13, the substrate position control device 48 shown in Fig. 12 is provided with a table 79 on which the mother base plate 38a is mounted, and a θ motor 81 which inplane-rotates the table 79, as shown by the arrow θ. In addition, as shown in Fig. 13, the main scanning drive device 49 shown in Fig. 12 is provided with a guide rail 82 extended to the main scanning direction X and a slider 83 which contains a linear motor that is pulse-driven. The slider 83 moves in parallel in the main scanning direction X along the guide rail 82 when the linear motor contained in the slider 83 is operated.

[0107]

In addition, as shown in Fig. 13, the sub-scanning drive device 51 shown in Fig. 12 is provided with guide rails 84 extended to the sub-scanning direction Y and a slider 86 which contains a linear motor that is pulse-driven. The slider 86 moves in parallel in the sub-scanning direction Y along the guide rails 84 when the linear motor contained in the slider 86 is operated.

[0108]

Each of the linear motors contained in the sliders 83 and 86 can be operated with high precision by controlling a rotation angle of an output shaft based on pulse signals to be supplied to the motors. Accordingly, the position of the ink jet head 52 that is supported on the slider 83 can be controlled in the main scanning direction X with high precision, and the position of the table 79 can be controlled in the sub-scanning direction Y with high precision. In addition to the above-described method in which the pulse motors are used, the positions of the ink jet head 52 and the table 79 may also be feedback-controlled using servo motors, or may be controlled by other arbitrary control methods.

[0109]

The substrate supply device 53 shown in Fig. 12 is provided with a substrate container 87 which contains the mother base plates 38a and a robot 88 which carries the mother base plates 38a. The robot 88 is provided with a base 89 which is disposed on an installation surface such as a floor, ground, etc., a lift shaft 91 which is lift-moved with respect to the base

89, a first arm 92 which rotates about the lift shaft 91, a second arm 93 which rotates with respect to the first arm 92, and an adsorption pad 94 which is disposed on the tip end bottom surface of the second arm 93. The adsorption pad 94 can adsorb the mother base plate 38a by air suction, etc.

[0110]

In Fig. 12, a capping device 106 and a cleaning device 107 are disposed at one side of the sub-scanning drive device 51, and under the ink jet head 52 which is driven by the main scanning drive device 49 and is main-scan-moved. In addition, an electronic force balance 108 is disposed at the other side of the sub-scanning drive device 51. The cleaning device 107 is a device used for cleaning the ink jet head 52. The electronic force balance 108 is a device used for measuring the weight of an ink drop to be ejected from each nozzle 57 of the ink jet head 52. In addition, the capping device 106 is a device used for suppressing the nozzles 57 from being dried out when the ink jet head 52 is in a standby state.

[0111]

An ink jet head camera 111 is disposed near the ink jet head 52 in such a manner that the ink jet head camera 111 and the ink jet head 52 are able to move together. In addition, a substrate camera 112 supported by a support device (not shown) provided on the base 39 is disposed at a position in which the substrate camera 112 can shoot the mother base plate 38a.

[0112]

The control device 54 shown in Fig. 12 is provided with a main computer 96 containing a processor, a keyboard 97 as an input device, and a Cathode Ray Tube (CRT) display 98 as a display device. As shown in Fig. 17, the above-described processor is provided with a Central Processing Unit (CPU) which performs calculation processing and a memory, i.e., an information storage medium 101, that stores various information.

[0113]

As shown in Fig. 17, the head position control device 47, the substrate position control device 48, the main scanning drive device 49, and the sub-scanning drive device 51 shown in Fig. 12, and a head drive circuit 102 which drives the piezoelectric elements 71 (see Fig. 16(b)) within the ink jet head 52 are connected to the CPU 99 via an input/output interface 103 and a bus 104. In addition, the substrate supply device 53, the input device 97, the display 98, the electronic force balance 108, the cleaning device 107, and the capping device 106 are also connected to the CPU 99 via the input/output interface 103 and the bus 104.

[0114]

The memory 101 is a concept including an external storage device or the like such as a semiconductor memory, e.g., Random Access Memory (RAM), Read Only Memory (ROM), etc., a hard disk, a CD-ROM reading device, a disk type storage medium, etc. A memory area for storing a software program in which a control procedure of an operation of the ink jet device 46 is described; a memory area for storing the main scanning movement amount of the slider 83 in the main scanning direction X and the sub-scanning movement amount of the mother base plate 38a in the sub-scanning direction Y shown in Fig. 13; an area which serves as a work area for CPU 99, a temporary file, etc., and various other memory areas are set.

[0115]

In this embodiment of the manufacturing method of a liquid crystal device, particularly in the color filter manufacturing method, the ink jet device 46 is used in both the subpixel formation process P32 and the protecting film formation process P33 shown in Fig. 11. The ink jet device 46 used in the subpixel formation process P32 and the protecting film formation process P33 can use substantially mechanically the same device.

[0116]

As shown in Fig. 17, the memory 101 contained in the ink jet device 46 used in the subpixel formation process P32 stores a software program which controls the general procedure of forming the subpixels; RGB formation position data which accomplishes desired subpixel arrangement of Fig. 4; and RGB adhesion amount data, which regulates the amount of each color material to be supplied to the respective positions of R, G, B. The RGB adhesion amount data can be determined based on the colors, or based on coordinates on the mother base plate 38a.

[0117]

While the ink jet head 52 is moved in the main scanning direction, based on the RGB formation position data and the RGB adhesion amount data, the CPU 99 related to the ink jet device 46 for subpixel formation calculates the timing, that is, when the subpixel material should be ejected, and which one of a plurality of nozzles 57 is used to eject the subpixel material.

[0118]

Similarly to the ink jet device 46 used in the subpixel formation process P32, the memory 101 of Fig. 17 provided with the ink jet device 46 used in the protecting film formation process P33 stores a software program which controls the general procedure of forming the protecting film; RGB formation position data which accomplishes desired subpixel arrangement of Fig. 4; and RGB adhesion amount data which regulates the amount of the respective color materials to be supplied to the respective positions of RGB.

[0119]

While the ink jet head 52 is moved in the main scanning direction, based on the RGB formation position data and the RGB adhesion amount data, the CPU 99 related to the ink jet device 46 for protecting film formation calculates the timing, that is, when the protecting film material should be ejected, and which one of a plurality of nozzles 57 is used to eject the protecting film material. For example, as shown in Fig. 5(a), if the volume of the protecting film material to be ejected is determined such that the top surface of the protecting films 17 and the top surface of the bank 14 are made substantially equal, the CPU 99 subtracts the volume of the subpixel 16 from the capacity of the grid-shaped holes formed by the bank 14, and determines the calculated difference as the volume of the protecting film material to be ejected.

[0120]

Instead of storing the RGB adhesion amount data, as the memory 101 for the ink jet device 46 for protecting film formation, the specific volume of the protecting film [material] to be ejected in accordance with the respective subpixels of RGB can also be directly stored.

[0121]

The CPU 99 of Fig. 17 performs controlling for ejecting ink, i.e., the subpixel material or the protecting film material to predetermined positions of the surface of the mother base plate 38a according to the software program stored in the memory 101. As specific functional accomplishing portion, the CPU 99 includes a cleaning calculator which performs calculations for a cleaning process; a capping calculator which performs calculations for a capping process; a weight measurement calculator which performs calculations for a weight measuring process using the electronic force balance 108 (see Fig. 12); and a drawing calculator which performs calculations for drawing the subpixel material or the protecting film material by the ink jet method.

[0122]

The drawing calculator can be divided into various functional calculators, i.e., a starting position calculator which performs calculations for setting an initial position at which the ink jet head 52 starts drawing; a main scanning control calculator which performs control-calculations for scan-moving the ink jet head 52 in the main scanning direction X at a predetermined speed; a sub-scanning control calculator which performs control-calculations for shifting the mother base plate 38a by only a predetermined sub-scanning amount in the sub-scanning direction Y; and a nozzle ejection control calculator which performs calculations for controlling the timing in which one of the plurality of nozzles 57 within the ink jet 52 are operated, so ink, that is, the subpixel material or protecting film material should be ejected.

[0123]

Although the above-described functions are realized by the CPU 99 based on the software program in this embodiment, a separate electronic circuit in which the above-mentioned respective functions do not use CPU may also be used.

[0124]

The operation of the ink jet device 46, which is constructed as described above, will be described below with reference to a flowchart shown in Fig. 18.

[0125]

When an operator turns on the power and the ink jet device 46 is operated, initial setting is first performed in step S1. Specifically, an initial state in which the head unit 56, the substrate supply device 53, the control device 54, etc. are predetermined is set.

[0126]

Then, when the weight measurement timing arrives (YES in step S2), the head unit 56 of Fig. 13 is moved to the electronic force balance 108 of Fig. 12 by the main scanning drive device 49 (step S3), and the volume of ink to be ejected from each nozzle 57 is measured by using the electronic force balance 108 (step S4). Then, the voltage to be applied to the piezoelectric element 71 corresponding to each nozzle 57 is adjusted in accordance with the ink ejection characteristic of each nozzle 57 (step S5).

[0127]

Then, when the cleaning timing arrives (YES in step S6), the head unit 56 is moved to the cleaning device 107 by the main scanning drive device 49 (step S7), and the cleaning device 107 cleans the ink jet head 52 (step S8).

[0128]

When the weight measurement timing or the cleaning timing does not arrive (no in steps S2 and S6), or when the processings are completed in step S9, the mother base plate 38a is supplied to the table 79 by operating the substrate supply device 53 of Fig. 12. Specifically, the mother base plate 38a inside the substrate container 87 is suction-held by the adsorption pad 94, is transferred to the table 79 by moving the lift shaft 91, the first arm 92, and the second arm 93, and is pushed against positioning pins 80 (see Fig. 13) which are pre-arranged at suitable positions of the table 79. In order to prevent the position shift of the mother base plate 38a on the table 79, the mother base plate 38a is preferably fixed to the table 79 by means such as air suction, etc.

[0129]

Then, the output shaft of the θ motor 81 of Fig. 13 is rotated in minute angular unit while the mother base plate 38a is observed by the substrate camera 112 of Fig. 12, so the table 79 is inplane-rotated in minute angular unit. Accordingly, the mother base plate 38a is positioned (step S10). Then, while the mother base plate 38a is observed by the head camera 111 of Fig. 12, the position to start drawing is calculated and determined by the ink jet head 52 (step S11), and the main scanning drive device 49 and the sub-scanning drive device 51 are operated such that the ink jet head 52 is moved to the drawing start position (step S12). As shown in Fig. 19, the ink jet head 52 is set such that the extending direction Z of the nozzle line 58 of each head portion 50 is perpendicular to the main scanning direction X.

[0130]

In Fig. 18, in step S12, after the ink jet head 52 is placed at the drawing start position, the ink jet head 52 starts to move in the main scanning direction X in step S13, and the ink ejection starts at the same time. Specifically, the main scanning drive device 49 of Fig. 13 is operated, and the ink jet head 52 is linearly scan-moved in the main scanning direction X shown in Fig. 19 at a constant speed. While the ink jet head 52 is moved, the nozzles 57 eject the subpixel material or the protecting film material when they reach the sections in which the subpixel material or the protecting film material is to be ejected. Thus, the sections are filled. Fig. 19(b) schematically shows a state in which the subpixel material M or the protecting film material M is ejected to the sections formed by the bank 14 in the form of ink drops.

[0131]

In Fig. 19(a), when the ink jet head 52 finishes one main scanning operation with respect to the mother base plate 38a (YES in step S14), the ink jet head 52 reversely moves and returns to the initial position (step S15). Then, the sub-scanning drive device 51 drives the ink jet head 52 by a predetermined sub-scanning amount in the sub-scanning direction Y, for example, only the length of a single nozzle line 58 or the integral multiple moves (step S16). Then, the main scanning and ink ejection are repeated, and the subpixels 16 or the protecting films 17 are formed in the sections in which the subpixels 16 or the protecting films 17 are not yet formed (step S13).

[0132]

After the ink jet head 52 finishes a single main scan, the ink jet head 52 may be immediately moved in the sub-scanning direction Y without moving the ink jet head 52 back to the initial position. After the sub-scanning movement is completed, main scanning is performed in the direction opposite to the previous main scanning direction while ink, i.e., the subpixel material or the protecting film material is ejected. Thus, ejection control can be performed. That is, in this case, main scanning for ejecting ink during both forward and return movement is performed when the ink jet head 52 is moved back and forth.

[0133]

When the ink jet head 52 finishes the drawing operation of the subpixels 16 or the protecting films 17 over the entire area of the mother base plate 38a (YES in step S17), the processed mother base plate 38a is output to the outside by the substrate supply device 53 or other transfer device in step S18. Then, unless a command to end the processing is issued by the operator (NO in step S19), the process returns to step S2, and the operation of ejecting the subpixel material or the like to another mother base plate 38a is repeatedly performed.

[0134]

When the command to end the operation is issued by the operator (YES in step S19), CPU 99 transfers the ink jet head 52 to the capping device 106 shown in Fig. 12. Then, the ink jet head 52 is subject to the capping processing by the capping device 106 (step S20). Accordingly, patterning of the subpixels 16 or the protecting films 17 for each subpixel 16 constituting the color filter 11 is completed. Then, the first electrode formation process which was already explained in process P3 of Fig. 9 is performed.

[0135]

As described above, according to the manufacturing method of a liquid crystal device of this embodiment, each of the subpixels 16 shown in Fig. 11 is formed by the ink jet method. Thus, the relationship between the openings 18 formed in the light reflecting film 9 and the subpixels 16 can be individually adjusted, so the colors displayed by the subpixels 16 can be finely adjusted. Accordingly, uniform color display can be realized in a plane.

[0136]

Fig. 15 shows a modification of the head portions 50 shown in Fig. 14(b). With reference to Fig. 14(b), each of the head portions 50 is provided with a single nozzle line 58 in the main scanning direction X. In addition, in Fig. 15 the head portion 50 may also be provided with a plurality of nozzle lines 58 which are arranged in the main scanning direction X. In this embodiment, two nozzle lines 58 are formed. By using this head portion 50, since the ink can be ejected from two lines of nozzles 57 arranged in the main scanning direction X, ejection amount of the subpixel material or the protecting film material can be controlled in various ways while the carriage 55 of Fig. 14(a) is moved in the main scanning direction X.

[0137]

Fig. 20 shows a main process, especially, a color filter formation process, of the manufacturing method of a liquid crystal device related to this invention. This process is performed in place of the process shown in Fig. 19 which is already described in the above-described embodiment. Additionally, the color filter manufactured by the manufacturing method of this embodiment is the same as the color filter shown by symbol "11" of Fig. 5. Furthermore, the color filter 11 can simultaneously form a plurality of liquid crystal panels on the mother base plate 38a shown in Fig. 10(a).

[0138]

Additionally, arrangement of the subpixels formed in the color filter 11 can be variously arranged such as striped arrangement shown in Fig. 4. The color filter 11 may be formed by the processes shown in Fig. 11 (processes P31-P33). In addition, the ink jet device used in the subpixel formation process P32 and the protecting film forming process P33 can use a device with a structure as shown in Fig. 12.

[0139]

As is clear from the comparison of Figs. 19 and 20, this embodiment is different from the above-described embodiment in that, when the ink jet head 52 is disposed at the initial position, that is, at the main scan starting position with respect to the mother base plate 38a, the entire body of the carriage 55 is inclined at an angle θ with respect to the sub-scanning direction Y. Thus, the extending direction Z of six nozzle lines 58 is also inclined at the angle θ with respect to the sub-scanning direction Y.

[0140]

According to the structure of this embodiment, the head portions 50 are moved in the main scanning direction X while they are inclined at the angle θ with respect to the sub-scanning direction Y. Thus, the pitch between the plurality of nozzles 57 formed in each head portion 50 can be made the same as the pitch between the sections in which the subpixels and the protecting films are formed, that is, the pitch between the elements, on the mother base plate 38a. When the pitch between the nozzles and the pitch between the elements are geometrically made the same, it is not necessary to position-control the nozzle lines 58 in the sub-scanning direction Y, so it is convenient.

[0141]

Fig. 21 shows a main process, especially, another color filter forming process, of the manufacturing method of a liquid crystal device related to this invention. This process is also performed in place of the process shown in Fig. 19 which is already described in the above-described embodiment. The color filter substrate manufactured by the manufacturing method of this embodiment is the same as the color filter shown by symbol "11" of Fig. 5. In addition, the color filter 11 forms a plurality of liquid crystal panel portions on the mother base plate 38a shown in Fig. 10(a).

[0142]

Additionally, the arrangement of the subpixels formed in the color filter 11 may be variously arranged such as striped arrangement shown in Fig. 4. The color filter 11 may be formed by the processes shown in processes P31-P33 of Fig. 11. Furthermore, the ink jet device used in the subpixel forming process P32 and the ink jet device used in the protecting film forming process P33 may be constituted as shown in Fig. 12.

[0143]

As is clear from the comparison of Figs. 19 and 21, this embodiment is different from the above-described embodiment in that, when the ink jet head 52 is disposed at the initial position, that is, at the main scan starting position with respect to the mother base plate 38a, six head portions 50 are inclined at an angle θ with respect to the sub-scanning direction Y although the entire body of the carriage 55 is not inclined in the sub-scanning direction Y. Thus, the extending direction Z of each nozzle line 58 is inclined at the angle θ with respect to the sub-scanning direction Y.

[0144]

According to the structure of this embodiment, the nozzle lines 58 are moved in the main scanning direction X while they are inclined at the angle θ with respect to the sub-scanning direction Y. Thus, the pitch between the plurality of nozzles 57 formed in each nozzle line 58 can be made the same as the pitch between the sections in which the subpixels and the protecting films are formed, that is, the pitch between the elements, on the mother base plate 38a. When the pitch between the nozzles and the pitch between the elements are geometrically made the same, it is not necessary to position-control the nozzle lines 58 in the sub-scanning direction Y, so it is convenient.

In addition, according to this embodiment, the entire body of the carriage 55 is not inclined as shown in Fig. 20; rather, the individual head portions 50 are inclined. Thus, the distance between the nozzle 57 that is closest to the mother base plate 38a to be ejected and the nozzle 57 that is farthest from the mother base plate 38a can be significantly reduced relative to the case shown in Fig. 20. Thus, the time of main scanning in the X direction can be reduced, so the manufacturing time of the color filter substrate can be reduced.

[0145]

(Other Embodiments)

Although the preferred embodiments of this invention have been described, this invention is not limited to the above-described embodiments, and various modifications can be made within the scope of this invention which is disclosed in the claims.

[0146]

For example, although the R, G, and B subpixels are used in the above-mentioned descriptions, for example, C (cyan), M (magenta), and Y (yellow) subpixels may also be used. In such a case, materials for forming the subpixels of C, M, and Y may be used instead of the materials for forming the R, G, and B subpixels.

[0147]

In addition, in the above-described embodiments, although six head portions 50 are disposed in the ink jet head 52 as shown in Fig. 14, the number of head portions 50 may be increased or reduced.

[0148]

In addition, in the embodiment shown in Figs. 10(a) and 10(b), a plurality of lines of liquid crystal panel formation sections 3a and 3b are formed in the mother base plates 38a and 38b, respectively. However, this invention may also be applied to the case in which a single line of liquid crystal panel formation region 3a is formed in the mother base plates 38a and 38b. In addition, this invention may also be applied to the case in which only one liquid crystal panel formation sections 3a and 3b having substantially the same as or significantly smaller than the mother substrates **[previously described as "mother base plates"]** 38a and 38b are set in the mother base plates 38a and 38b.

[0149]

In addition, in the ink jet device 46 shown in Figs. 12 and 13, the ink jet head 52 is moved in the X direction for main scanning over the base plate 38a. In addition, the base plate 38a is moved in the Y direction by the sub-scanning drive device 51 for the sub-scanning of the ink jet head 52 over the base plate 38a. However, conversely, the [mother] base plate 38a may be moved in the Y direction for the main scanning, and the ink jet head 52 may be moved in the X direction for the sub-scanning.

[0150]

Additionally, in the above-described embodiments, although the ink jet head with a structure in which ink is ejected by using flexure-deformation of piezoelectric elements, an ink jet head having other arbitrary structure can also be used.

[0151]

[Effects of the Invention]

As described above, according to the liquid crystal device related to this invention and the manufacturing method, the openings are formed in the light reflecting film at regions corresponding to the thickest film parts of the subpixels. In addition, the openings are formed in the light reflecting film at regions corresponding to the central regions of the subpixels.

Furthermore, the openings are formed in the light reflecting film in such a manner that the openings extend in the longitudinal direction of the subpixels. Accordingly, uniform color display without color irregularities can be performed at the time of the transmissive display mode. Uniform color display between the reflective display mode and the transmissive display mode can be performed.

[Brief Description of the Drawings]

Fig. 1 is an exploded perspective view of an embodiment of a liquid crystal device according to this invention.

Fig. 2 is an I-I cross-sectional view showing a cross-sectional structure of the liquid crystal device of Fig. 1.

Fig. 3 is an enlarged view of a part shown by an arrow D in Fig. 1.

Fig. 4 **[Figs. 4(a), (b), and (c)]** shows diagrams showing examples in which a plurality of various subpixels are arranged in a color filter.

Fig. 5 **[Figs. 5(a), (b), and (c)]** shows structures of one pixel portion of an example of a color filter. Fig. 5(a) is a cross-sectional view of subpixels in a shorthand direction, Fig. 5(b) is a plan view, and Fig. 5(c) is a cross-sectional view of one of the subpixels in a longitudinal direction.

Fig. 6 **[Figs. 6(a), (b), and (c)]** shows structures of one pixel portion of another example of a color filter. Fig. 6(a) is a cross-sectional view of subpixels in the shorthand direction, Fig. 6(b) is a plan view, and Fig. 6(c) is a cross-sectional view of one of the subpixels in the longitudinal direction.

Fig. 7 **[Figs. 7(a), (b), and (c)]** shows structures of one pixel portion of other example of a color filter. Fig. 7(a) is a cross-sectional view of subpixels in the shorthand direction, Fig. 7(b) is a plan view, and Fig. 7(c) is a cross-sectional view of one of the subpixels in the longitudinal direction.

Fig. 8 **[Figs. 8(a) and (b)]** shows diagrams explaining other formation method of a color filter. Fig. 8(a) shows an example of a measurement system of interference fringes, and Fig. 8(b) schematically shows interference fringes obtained by the measurement system.

Fig. 9 is a flowchart showing an embodiment of a manufacturing method of a liquid crystal device according to this invention.

Fig. 10 **[Figs. 10(a) and (b)]** shows plan views schematically showing mother substrates obtained in one process of the manufacturing method of Fig. 9.

Fig. 11 shows process diagrams showing an embodiment of a process of forming a color filter which is one process of the manufacturing method of Fig. 9.

Fig. 12 is a perspective view showing an embodiment of an ink jet device used in one process of the manufacturing method shown in Fig. 11.

Fig. 13 is an enlarged perspective view of a major part of the device of Fig. 12.

Fig. 14 **[Figs. 14(a), (b), and (c)]** shows perspective views showing an embodiment of an ink jet head used in the device of Fig. 12, and an embodiment of head portions used in the ink jet head.

Fig. 15 is a perspective view showing a modification of the head portion of the ink jet head.

Fig. 16 **[Figs. 16(a) and (b)]** shows diagrams showing an internal structure of the head portion of the ink jet head. Fig. 16(a) is a partially broken perspective view, and Fig. 16(b) is a J-J cross-sectional view of Fig. 16(a).

Fig. 17 is a block diagram showing an electrical control system used in the ink jet device of Fig. 12.

Fig. 18 is a flowchart showing a control flow implemented by the control system of Fig. 17.

Fig. 19 **[Figs. 19(a) and (b)]** shows plan views schematically showing a main process of an embodiment of a color filter formation process, which is a main process of a manufacturing method of a liquid crystal device related to this invention.

Fig. 20 **[Figs. 20(a) and (b)]** shows plan views schematically showing a main process of another embodiment of a color filter formation process, which is a main process of a manufacturing method of a liquid crystal device related to this invention.

Fig. 21 **[Figs. 21(a) and (b)]** shows plan views schematically showing a main process of other embodiment of a color filter formation process, which is a main process of a manufacturing method of a liquid crystal device related to this invention.

[Explanation of the Symbols]

1: Liquid crystal device

2: Liquid crystal panel

3a, 3b: Substrates

4: Sealing member

8a, 8b: Base plates

9: Light reflecting film

11: Color filter

12a, 12b: Electrodes

14: Bank (partitioning member)

16: Subpixels

17: Protecting film

18: Opening

22: Switching element

28: Grid hole (subpixel formation section)

33a, 33b: Mother substrates

38a, 38b: Mother base plates

46: Ink jet device

52: Ink jet head

57: Nozzle

58: Nozzle line

69: Ink pressure body

71: Piezoelectric element

F: Interference fringe

L: Liquid crystal

M1, M2: Chamfers

M6, M7: Materials

P: Central regions of sections

R0: Natural light

T0: Reference value

X: Main scanning direction

Y: Sub-scanning direction

[Document] ABSTRACT

[Abstract]

[Object] To provide a transflective type liquid crystal device in which color display can be constantly made uniform in both a reflective display mode and a transmissive display mode.

[Solving Means] A liquid crystal device 1 is provided with a light reflecting film 9 formed on a substrate 3a of a pair of substrates 3a and 3b which sandwich liquid crystal L, and a color filter 11 formed on the light reflecting film 9. The color filter 11 is provided with a partitioning member 14 which divides a surface of the substrate 3a into a plurality of sections, and subpixels 16 formed in the sections. The light reflecting film 9 is provided with openings 18 corresponding to the thickest film parts of the subpixels 16, openings 18 corresponding to central parts of the plurality of partitioning sections, openings 18 which extend in a longitudinal direction of a plurality of rectangle-shaped sections, or openings 18 formed in a shape corresponding to the thickness of the subpixels 16.

[Selected Figure] Fig. 1

Fig. 4

(a) Striped

(b) Mosaic

(c) Delta

Fig. 9

(First substrate)

P1	Reflecting film formation
P2	Color filter formation
P3	First electrode formation
P4	Orientation film formation
P5	Rubbing processing
P6	Sealing member formation
P7	Spacer dispersion

(Second substrate)

P11	Element formation
P12	Second electrode formation
P13	Orientation film formation
P14	Rubbing processing

P21	Attachment
P22	Primary cut
P23	Liquid crystal injected and injection port sealed
P24	Liquid crystal cleaned
P25	Secondary cut
P26	Mounting
P27	Polarizing plate attached

Fig. 11

Color filter formation

↓

P31 Bank formation process

↓

P32 RGB subpixel formation process

↓

P33 Protecting film formation process

Fig. 16

Ink supply device-67

Fig. 17

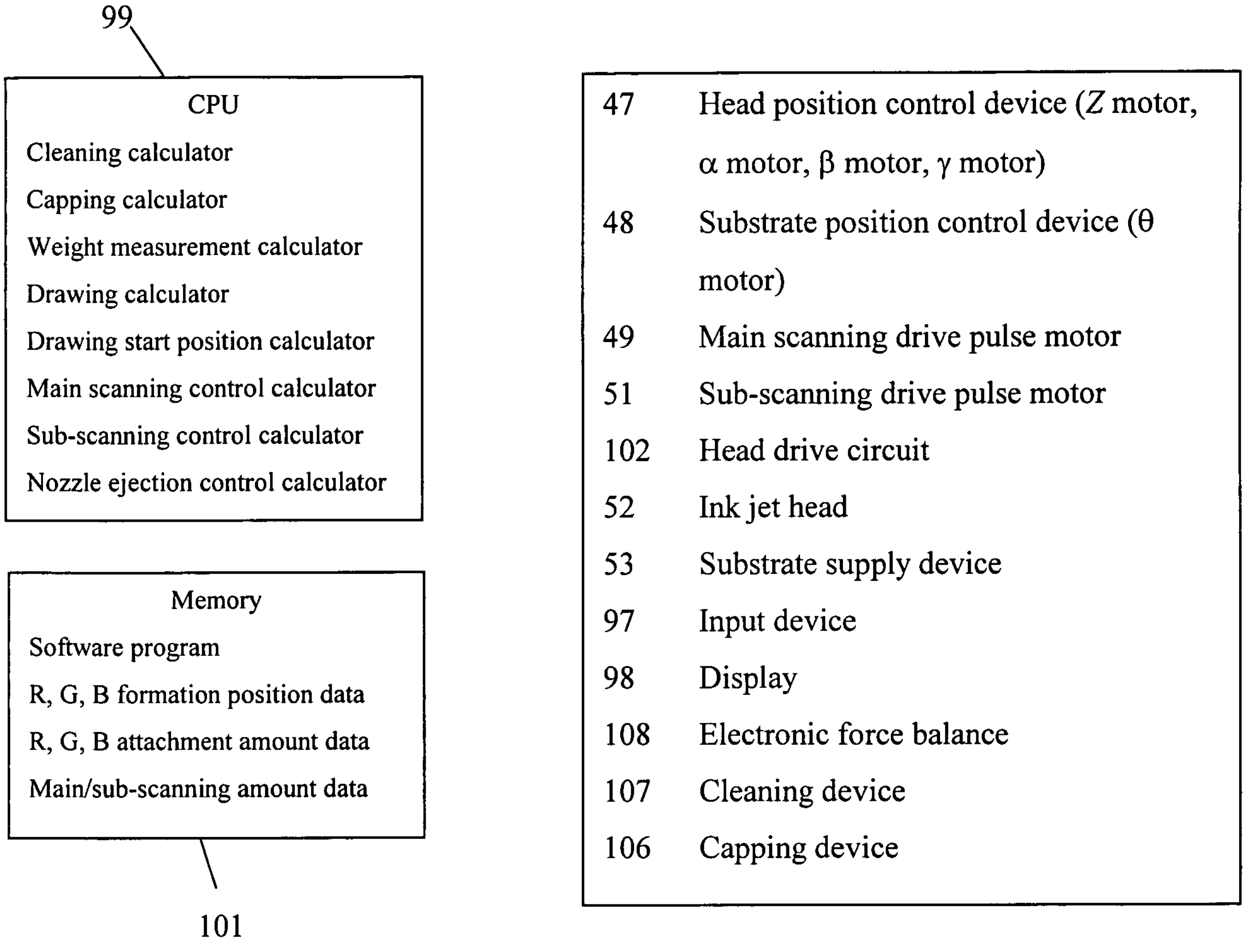
99
CPU
Cleaning calculator
Capping calculator
Weight measurement calculator
Drawing calculator
Drawing start position calculator
Main scanning control calculator
Sub-scanning control calculator
Nozzle ejection control calculator
Memory
Software program
R, G, B formation position data
R, G, B attachment amount data
Main/sub-scanning amount data
101
47 Head position control device (Z motor, α motor, β motor, γ motor)
48 Substrate position control device (θ motor)
49 Main scanning drive pulse motor
51 Sub-scanning drive pulse motor
102 Head drive circuit
52 Ink jet head
53 Substrate supply device
97 Input device
98 Display
108 Electronic force balance
107 Cleaning device
106 Capping device

Fig. 18

Start

S1 Initial setting

S2 Weight measurement timing?

S3 Head moves to electronic force balance

S4 Ink weight measurement

S5 Ink ejection voltage controlled

S6 Cleaning timing?

S7 Head moves to cleaning portion

S8 Cleaning

S9 Base plate supply (positioning pin)

S10 Base plate positioning (θ rotation)

S11 Drawing start position determined

S12 Head moves to drawing start position

S13 Main scanning and ink ejection

S14 One scanning completed?

S15 Return movement

S16 Sub-scanning movement

S17 The entire mother substrate scanned?

S18 Substrate output

S19 Drawing completion instructed?

S20 Capping

End